Magnetic phase transition, as a possible source of crustal conductivity anomalies?

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As possible sources of the observed electrical conductivity anomalies in the Earth’s crust (at mid-crustal depths of 15-20 km in shield regions, and at depths of 8-10 km in younger regions with higher heat-flow value) usually the following four candidates (with two possible mechanisms: ionic- and electronic conductions) are considered: (1a) aqueous fluids (saline water), (1b) partial melts, (2a) carbon grain-boundary films, (2b) conducting minerals. On basis of a combined magnetotelluric-geomagnetic-geothermic-thermodynamic consideration, we are proposing a further physical mechanism, namely the magnetic phase transition taking place at the Curie temperature (or the Néel temperature for antiferromagnetic materials). As it was shown both by theory and experiments, instead of a monotonous transition, the magnetic susceptibility at the critical temperature may have a significant (theoretically: infinite) local enhancement, before its vanishing at high temperatures. A high value of magnetic permeability (which is commonly neglected in magnetotelluric studies) manifests itself as an apparent enhancement of the electrical conductivity. It is a statistical fact that inverted depths corresponding to electrical conductivity anomalies often coincide with the depths of possible critical temperatures. The vertical extension of magnetic phase transition conditions in the Earth’s crust is probably not more than a few hundred meters. Such a thin and narrow, but strongly magnetized, and elongated zones at the critical depth are already able to produce both electrical conductivity- and accompanying geomagnetic anomalies. We discuss in details one of the suspicious anomalies, observed in the crust in SW-Hungary in a magnetotelluric field campaigne.

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